CURRENT LITERATURE

NOTES FOR STUDENTS

Ecology of the Santa Catalina Mountains.—The Santa Catalina Mountains of southeastern Arizona afford unusual opportunities for ecological studies by displaying a rich vegetation in the midst of a semi-arid region. They rise from a basal elevation of 3000 feet to a height of 9150 feet, and their proximity to Tucson has lead to their study by members of the staff of the Desert Laboratory and of the University of Arizona. As a result of such an investigation, SHREVE[1] has made an analysis of the vegetation in relation to climatic factors. In general these mountains are characterized by rugged ridges of gneissic rock, and steep, rather narrow, drainage canyons without mountain parks or meadows. Only above 7500 feet is there any modification of the soil due to the accumulation of humus, while below that altitude the pockets and crevices are filled with a loam soil mixed and often with its surface covered with coarse angular fragments. About the base of the mountain are alluvial slopes of straight profile accumulated by violent and intermittent stream flow, and designated by their popular Spanish name "bajada." In this study the vegetation of the upper bajadas is included, giving a picture of the plant life by which the higher elevations are surrounded and from which they derive many of their characteristic species.

Three vegetational regions are distinguished: the desert, with an altitudinal range from 3000 feet on the upper bajadas to 4000–4500 feet upon the mountain slopes; the scrub or semi-desert, here designated "encinal," with an upward limit of 6000–7000 feet; and forest reaching to and most highly developed upon the mountain tops. The desert vegetation of the upper bajadas and mountain slopes differs from that of the lower plains principally in the greater number both of species and of individuals there present, but agrees in general openness of stand, lowness of stature, and diversity of types, comprising principally such forms as stem succulents, microphyllous and sclerophyllous shrubs, macrophyllous deciduous shrubs, perennial grasses, root perennials, and ephemeral herbaceous plants. Conspicuous examples of such types are seen in *Cereus giganteus, Echinocactus* spp., *Opuntia* spp., *Prosopis velutina, Acacia Greggii, Parkinsonia microphylla, Covillea tridentata, Fouquiera splendens, Jatropha cardiophylla,* and *Franseria deltoidea;* while at the upper

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[1] SHREVE, FORREST, The vegetation of a desert mountain range as conditioned by climatic factors. Carnegie Inst. Wash. Publ. no. 217. pp. 112. *pls. 36. figs. 17.* 1915.

transition portion *Prosopis* and other shrubs, together with several grasses, become more abundant, and such forms as *Agave Palmeri* and *Dasylirion Wheeleri* appear. In the encinal the grass cover largely persists, although small evergreen trees and shrubs are the distinctive feature of the vegetation. Among the most abundant of these are several species of *Quercus*, *Juniperus pachyphloea*, *Pinus cembroides*, *Arctostaphylos pungens*, *Mimosa biuncifera*, *Rhus trilobata*, *Garrya Wrightii*, and *Vauquelinia californica*. Herbaceous perennials are also abundant.

The forest begins at about 6000 feet, with an open stand of *Pinus arizonica*, in which the evergreen oaks of the encinal become gradually more scattered. At slightly higher elevations *Arbutus arizonica*, *Pseudotsuga mucronata*, and *Pinus strobiformis* begin to be found, while the shrubby and herbaceous flora gradually changes by the appearance of less xerophytic forms. This forest reaches its highest expression by the appearance of *Abies concolor* above 7000 feet, where the individual trees are larger and the stand becomes close and heavy. Such a mesophytic conifer forest in the midst of a desert calls for a close analysis of the climatic factors involved. The location of the Santa Catalina Mountains in a continental desert gives their lower slopes the climate characteristic of this desert, its main features being a low rainfall unequally distributed, a short winter with severe frost, and a long summer with high temperatures and low humidity. The major portion of the rainfall is confined to a short but well marked rainy season in July and August, within which a little over half of the annual precipitation usually occurs. At Tucson this has averaged 6.6 inches during the years 1907–1912, while in the mountains, although there have been very few observations, the average for the years 1907–1914 inclusive, at stations at 7600 feet, for the humid midsummer, was 17.45 inches, or a probable annual average of 35 inches. The frostless season decreases from a range extending from March to December at Tucson, to one from the middle of May to the beginning of October at 8000 feet, but perhaps the change at higher altitudes most important in its effect upon vegetation is the prolongation of spring shortening the arid fore-summer from 15 weeks on the desert, to 11 weeks at 6000 feet, and 6 weeks at 8000 feet. The influence of this modification will become apparent when it is recalled that this is the most trying season of the year, and the one in which moisture conditions are critical for the survival of individuals or species. The humid midsummer, on the contrary, is the season when conditions upon the desert and in the mountain are most alike, and during which there is the greatest vegetative activity in both habitats. A close analysis of these effects of the variations in the amount and distribution of the rainfall is given, together with a few data regarding the resulting conditions of soil moisture.

The evaporative power of the air was determined by the use of standard atmometers at six stations, situated at regular intervals of 1000 feet from 3000 to 8000 feet. At each station a pair of instruments, one with a north exposure and the other with a south exposure, were used, and some data were secured during 1908 and 1910, and a more complete set of observations was obtained during the summer of 1911. These results are expressed in an interesting series of graphs, with evaporation rates ranging from approximately 100 cc. per day from the standard atmometer at 3000 feet during April and May, and half that amount during the more humid July and August, to about 15 cc. per day during the latter months at 8000 feet. The need of data from a larger number of stations for a series of years is recognized, but from those obtained the following conclusions are drawn: (1) the rate of evaporation through the arid and humid summer seasons is about 3.5 times as great on the desert as it is at 8000 feet; (2) the rates of evaporation are approximately half as great in humid midsummer as they are in arid fore-summer; (3) at the middle and higher altitudes the evaporation on north slopes is less than on south slopes; and (4) the difference between the amounts of evaporation on north and south slopes becomes greater with increase of altitude in proportion to the amounts of each. Corresponding with the high rates of evaporation are low values of relative humidity. A considerable amount of temperature data has been secured, its most important bearings having to do with the altitudinal shortening of the frostless season, the altitudinal fall in temperature, the daily maxima and minima at various altitudes, and the absolute minima of winter. These data show that the lowest temperatures of winter ($-2°$ in 1913 and $15°5$ F. in 1914 at 7600 feet) are less severe on the Santa Catalinas than on the plateau of north central Arizona. The departure from the normal altitudinal gradient, due to the operation of cold air drainage, discussed in an earlier paper[2] and reviewed in this journal,[3] is supported by further data, and its importance in influencing vegetation is noted, and some soil temperature data seem to indicate that its winter minimum is decidedly above that of the air. With such remarkable variety in vegetation and such extremes in physical factors, the correlation of vegetation and its controlling factors become of the utmost importance, and in no part of this report is the excellence of the work better shown than in SHREVE's discussion of the complex problems involved. With such a large gradient of climatic change, it might be expected that vertical distribution of species would be decidedly limited, and such is the case. No plant extends its range from the desert to the upper forest, and very few extend through half that gradient of conditions, while in general it may be said that most are limited to vertical ranges of less than 1500 feet in habitats of the same topographic character. A vertical range of 4700 feet for *Vitis arizonica* in canyons and ravines, 4200 feet for *Agave Palmeri* from the dry slopes at 3200 feet to high open ridges, and *Juniperus pachyphloea* from northern slopes at 4200 feet to ridges at 7900 feet are among the more extreme instances given. Moisture is recognized as the most critical factor controlling the vertical distribution of this vegetation, and the ratio of evaporation to soil moisture is

[2] SHREVE, FORREST, Cold air drainage. Plant World 15:110–115. 1912.

[3] BOT. GAZ. 55:263. 1913.

accepted as the best expression of the conditions which affect the water relations of plants. Unfortunately, the soil moisture data are too scanty to afford a good basis for comparison, and are not expressed in terms indicating what proportion of this moisture is available for plant production. The temperature control has been experimentally studied for a few species, and the results have been previously reported.[4] These are given some further consideration, while slope exposure and topographic relief are carefully discussed. Perhaps nothing shows the unusual character of the factors controlling vegetation more than the fact that succession due to physiographic development and to the reaction of the plant upon its habitat is almost completely absent.

In its efforts to determine in a quantitative manner the climatic and other physical factors involved, and in its careful attempts to correlate these factors with vegetation, this report may be regarded as an excellent example of modern ecological investigation. The illustrations are numerous, well chosen, and reproduced in the excellent manner that has usually characterized the publications of the Carnegie Institution, while the organization of the material presented is decidedly better than that of many similar publications that have come to the attention of the reviewer.—GEO. D. FULLER.

Vegetation and tide levels.—The excellent opportunities for investigating the problems of seashore vegetation at Cold Spring Harbor, New York, afforded by the location at that place of the Biological Laboratory of the Brooklyn Institute of Arts and Sciences and the Carnegie Station for Experimental Evolution has been appreciated by many botanists, and the factors determining the composition and distribution of the various plant associations in the vicinity are becoming better known. In 1912 JOHNSON and YORK[5] made a preliminary announcement of the results of a survey of the inner harbor, and indicated the relations of the various plant associations to tide levels. This was followed by a more general paper by TRANSEAU[6] on the littoral successions of the vicinity, devoted principally to a consideration of the lines of succession followed by the seed plant communities from the salt marsh to the pine barrens. More recently there has come the full report of the careful survey of JOHNSON and YORK,[7] who have confined their attention to the vegetation of the inner harbor.

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[4] SHREVE, FORREST, Influence of low temperatures on the distribution of the giant cactus. Plant World **14**:136–146. 1911.

———, The rôle of winter temperatures in determining the distribution of plants. Amer. Jour. Bot. **1**:193–202. 1914; see review in BOT. GAZ. **59**:502–503. 1915.

[5] JOHNSON, D. S., and YORK, H. H., The relation of plants to tide levels. Johns Hopkins Univ. Circular no. 2. pp. 6. 1912.

[6] TRANSEAU, E. N., The vegetation of Cold Spring Harbor, Long Island. I. The littoral succession. Plant World **16**:189–210. *figs. 1–8.* 1913.

[7] JOHNSON, D. S. and YORK, H. H., The relation of plants to tide levels. Carnegie Inst. Wash. Publ. no. 206. pp. 162. *pls. 24. figs. 5.* 1915.